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Monitoring Report on the Upper Ottawa Street Landfill Site [annual]

MONITORING PROGRAM REPORT
UPPER OTTAWA LANDFILL
SITE

Gartner Lee
Associates Limited

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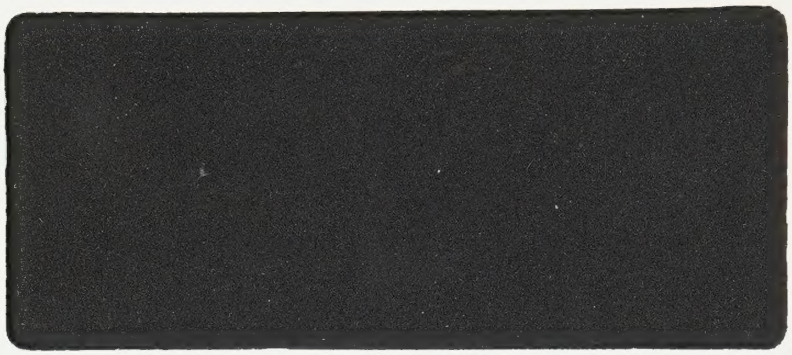

X Monitoring Program
8306 Report
.7135 Upper Ottawa
1983 Landfill Site

MONITORING PROGRAM REPORT

UPPER OTTAWA LANDFILL

SITE

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Gartner
Lee
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Consulting
Engineering
Geologists and
Hydrogeologists

Toronto-Buttonville Airport ■ Markham, Ontario ■ L3P 3J9 ■ 416-477-8400
Telex - 06-986278

MONITORING PROGRAM REPORT
UPPER OTTAWA STREET LANDFILL SITE

FOR

THE REGIONAL MUNICIPALITY OF
HAMILTON-WENTWORTH

PROJECT NO. 80-190

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JANUARY, 1983
(REVISED MARCH 1983)

Gartner Lee Associates Limited

Consulting Engineering Geologists and Hydrogeologists

Toronto-Buttonville Airport ■ Markham, Ontario ■ L3P 3J9 ■ 416-477-8400
Telex - 06-986278

March 31, 1983

Regional Municipality of Hamilton-Wentworth,
Department of Engineering,
71 Main Street West,
Hamilton, Ontario.
L8N 3T4.

Attention: Mr. J.R.G. Leach, P.Eng.
Commissioner of Engineering

Dear Sirs:

Re: Monitoring Program
Upper Ottawa Street Landfill Site
GLAL 80-190

We respectfully submit our final report for the above noted study as per your request. A draft copy of the report was reviewed by the Region and the Upper Ottawa Street Landfill Site Study committee and their comments were incorporated into the final report. The draft was issued in March 1982.

The report discusses the results of the gas, surface water and ground water monitoring which we carried out during the latter part of 1980 and during 1981. As well, the results of the inspection of Redhill Creek flood plain along with the laboratory analysis of ground water springs are documented and discussed. Finally the report outlines a recommended monitoring, inspection and testing program for 1982 and 1983.

Recommendations for the inspection and testing program for leachate movement and springs in the Redhill Creek flood plain are contained in section 2.4 of the report. The monitoring program for ground water, surface water and combustible gas is detailed in section 3.0.

We thank you for the opportunity to be of service on this most interesting study. If there are any questions, please contact us.

Yours very truly,

GARTNER LEE ASSOCIATES LIMITED

P.K. Lee, M.A.Sc., P.Eng.
Consulting Engineering Geologist.

DEJ:jcm

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APPENDIX

Ground Water and Gas Monitor Details
Geochemistry Results
Ground Water Elevations
Combustible Gas Results

A Site Plan is enclosed at the back of the Report.

1.0 INTRODUCTION:

1.1 BACKGROUND:

In the fall of 1978, Gartner Lee Associates Limited undertook a preliminary hydrogeological study for the Upper Ottawa Street landfill (report 78-119). Our 1978 report was used to identify concerns and potential problems related to leachate and methane gas aspects that were based on literature search data, field surface mapping and air-photo interpretation. One of the recommendations at that time was that a detailed sub-surface study be carried out to confirm the suspected impacts.

In August 1979, a detailed hydrogeological study of both the surface and subsurface settings was initiated in order to address both the suspected leachate and gas impacts. The report (number 79-78) was issued in September 1980. Results of that study showed that leachate was exfiltrating from the landfill into the dolomite bedrock and migrating off-site to the north, east and south in the rock joints and bedding planes. The contaminant plume trends off towards the Escarpment. Some of the leachate was entering Redhill Creek and the Creek contacted the waste along its northern boundary. The study showed that the creek was affected locally both from a chemical flux, and biologically. Finally although there was a potential for methane gas migration, no movement was detected. It was a recommendation of the detailed study that a detailed monitoring program be initiated to assess changes in the setting both within and outside the landfill.

Gartner Lee Associates Limited were retained by the Region in November 1980 to carry out the monitoring program for the Upper Ottawa Street Landfill Site according to the recommendations of our report 79-78. An extension to the program was authorized in October 1981.

1.2 STUDY PROGRAM:

The study program consisted of the following items:

a) The measurement of ground water levels and the collection of ground water samples in November 1980, and May 1981 at these seven stations:

   Borehole 1, - Installation 1
   Borehole 4, - Installation 1
   Borehole 6, - Installation 1
   Borehole 9, - Installation 1
   Borehole 11, - Installation 1
   Borehole 12, - Installation 1

b) The collection of surface water samples from Redhill Creek in November 1980 and May 1981 at the three stations, SW1, SW2 and SW4. Also included was the leachate pond (between landfill and railroad, near Redhill Creek).

c) The collection of sediment samples at SW1, SW2, and SW4 for PCB analysis by an independent laboratory in November 1980.

d) The inspection of the Escarpment face with the emphasis at the Albion Falls area. Also included was an inspection of the Redhill Creek flood plain between the railroad and Albion Falls for signs of leachate springs in November 1980 and May 1981.

e) Gas monitoring in November and December 1980.

f) The analysis and reporting of results.

The work was carried out in accordance with the outlined program. Our letter of January 19th, 1981 provided a brief summary of the initial findings and results of the November 1980 monitoring. On the completion of the May 1981 testing and analysis of results, we met with the Region and the Ministry of the Environment on October 5, 1981. As a result of that meeting, the program was extended to include additional water quality testing and inspection of the flood plain.

2.0 STUDY FINDINGS:

Detailed results of the monitoring are contained in the Appendix. These results include a) details on the ground water monitor locations and construction (Table 1),

b) ground and surface water chemistry (Tables 2 and 3), c) sediment chemistry (Table 4), d) chemistry of springs in the flood plain (Table 5), e) ground water elevations (Table 6), and f) combustible gas (Table 7). A site plan is enclosed at the back of the report to show monitoring locations and information related to the Redhill Creek flood plain inspection. The following sections of the report summarize the study results, discuss the significance of the findings and provide details of recommended follow-up work.

2.1 GROUND WATER:

The geochemical results of the present study are documented on Table 3 in the Appendix. Our previous work described in our report 79-78 was reviewed and analysed in conjunction with Table 3 to assist in developing our conclusions. This earlier data has not been included here. Following is a summary of our findings:

- Borehole 1 and borehole 12 are upgradient from the landfill site in the ground water flow system. The monitors sampled in these boreholes are screened in the bedrock near the contact of the Decew-Rochester Formations due to the thin saturated section available there in the overlying Lockport dolomite. Water quality in the Rochester shale is naturally poor compared with the quality in the dolomite. Thus the water samples tested are influenced by the shale water and we feel that they

provide only a rough guide for water quality comparisons downgradient.

- In borehole 4 which is located on the landfill itself, test results of the ground water in the bedrock under the refuse shows a general but slight increase in the concentration of most parameters from November 1980 to May 1981. Based on data obtained from 1979, there is a general tendency towards increased concentrations overall.

- In boreholes 6 and 9 located downgradient from the landfill and screened in the rock, the short term change in concentrations between November 1980 and May 1981 is small overall with some parameters increasing slightly while others decrease slightly. The longer term trend appears to be towards a gradual increase in concentrations of most parameters tested.

- In borehole 11, located downgradient from the landfill, concentrations of all non-organochlorines tested have generally increased very significantly in the monitoring period. The monitor in this borehole is screened near the Decew-Rochester contact, and thus is influenced by the shale water, previously described as naturally poor. This combines with possible leachate effects. Note the values of chloride, conductivity and sulphate in comparison with values with the waste itself at borehole 4.

- There are PCBs in trace concentrations in the leachate pond and in borehole 4, but none were detected in boreholes 6, 9 and 11.

- HCB and pp' DDE were detected in boreholes 4, 6, 9 and 11. No other organochlorines were detected in these boreholes.

The results of the monitoring program confirm that leachate is continuing to be produced in the landfill and is still exfiltrating in part into the ground water flow system in the bedrock. It is our present interpretation that the leachate plume extends north, south and east from the landfill. The chemistry results indicate that the concentration of the contaminant plume is still increasing for the most part. The significant increase in concentration of parameters in borehole 11 is attributed in part to the stabilizing of the ground water system after the infusion of foreign water from the drilling process, to naturally poor water quality in the shale bedrock, and possibly to leachate from the landfill. On-going monitoring will establish the long term trends at this station. Borehole 11 was drilled six months after boreholes 1 to 10 and thus appears to be the only location in which the ground water system is still stabilizing. There are a number of possible sources for the PCB and HCB in the ground water upgradient from the landfill. It is recommended that a soil sampling program be undertaken to identify the source of these parameters if possible. For the most part there are no organochlorines in the ground water except the trace of PCB, HCB and pp' DDE. The source of these organochlorines is likely the landfill.

In view of these findings we recommend that:

- *A ground water geochemical program should be carried out according to the details in section 3.0 of this report.*

A review of the ground water elevations indicates that:

- There are no significant trends of ground water levels. Variations appear to reflect those expected with the normal seasonal changes in a ground water system in the bedrock.

In view of this finding, we recommend that:

- *A ground water monitoring program should be carried out according to the details in section 3.1 of this report.*

2.2 SURFACE WATER:

A review and analysis of the detailed geochemical results including data documented in our report 79-78 for the surface water at stations SW1, SW2 and SW4 indicate the following findings:

- Station SW4 is located on Redhill Creek, upstream from the landfill site. There was an increase in the concentration of conductivity, chloride, ammonia, and kjeldahl and a decrease in concentration in iron, phenols and BOD between November 1980 and May 1981. The longer term trends indicate a general increase in chloride, conductivity and ammonia concentrations. Kjeldahl nitrogen appears to decrease with time in concentration. No other trends are apparent from the data.

- At station SW2 located on Redhill Creek below the landfill, there was a decrease in concentration in conductivity, chloride, kjeldahl, iron, phenols and BOD, and an increase in the concentration of ammonia between November 1980 and May 1981. The longer term trends based on additional data in report 79-78 indicate that the concentration of chlorides, conductivity and ammonia are increasing. No trends are apparent with the other parameters tested, and the data available.

- At SW2, the concentration of ammonia and kjeldahl nitrogen is higher than at SW4, while the concentration of chloride at SW2 is lower than at SW4 at the November 1980 and May 1981 sampling. There were no trends apparent for the other parameters.

- At station SW1, located at the pond above Albion Falls, there was a decrease in concentration of conductivity, chloride, kjeldahl, nitrogen, iron, phenols and BOD and a slight increase in ammonia between November 1980 ane May 1981. There are no long term trends apparent at SW1.

- At SW1, the concentration of the parameters tested are generally lower than at SW2 for the November 1980 and May 1981 sampling. Ammonia and kjeldahl nitrogen at SW1 is higher than at SW4 for the same period. No other trends are apparent with the other parameters.

Based on the geochemistry results, water quality of Redhill Creek above the landfill has generally deteriorated since

October 1979 when our first data was collected. This deterioration is attributed to upstream effects. Leachate is also entering Redhill Creek from the landfill. It appears that the leachate is contributing ammonia and kjeldahl in significant concentrations to the creek. Although the concentration of ammonia and kjeldahl decrease downstream towards SW1, the levels are still above background. Regarding the other parameters tested, the discharge into the creek from upgradient of the landfill appears to have a greater impact than the leachate. There is some recovery of Redhill Creek downstream towards Albion Falls, although ammonia and kjeldahl nitrogen remain high.

In view of these findings, we recommend that:

- *A surface water monitoring program, including stream flow measurements and mass balance calculations to fully assess the impact of leachate on the water quality, be carried out according to the details in section 3.2 of this report.*

2.3 Redhill Creek Sediment:

A review and analysis of the results of three sediment samples taken in Redhill Creek on November 25, 1980 indicate that:

- There is a trace of PCBs in the sediment at each of the three sampling locations.

- There are PCBs in the sediment upstream from the landfill near the piped section outlet of Redhill Creek.

- Concentrations of PCBs were significantly lower than the concentrations reported by Peninsula Chemical Analysis.

The presence of PCBs in the sediment upstream of the landfill indicates that there is another source not associated with the existing site. However, it is not known what the source is at this time. Also information is inconclusive as to the origin of PCBs in the sediment downstream from the landfill, although it is suspected that the landfill may be a contributor, at least partially. It is indicated though that the original results reported by Peninsula Chemical Analysis are in error, and that the actual concentrations are probably more typical of the recent test results. Further monitoring should be carried out to establish trends. Depending on these future results a decision can be made on the need to identify the source of the PCBs.

In view of these findings, we recommend that:

- *Sediment samples at SW1, SW2 and SW4 be analyzed for PCBs in November 1982 and 1983.*

2.4 Redhill Creek Flood Plain Inspection:

On November 30, 1980, Mr. Jagger carried out a detailed inspection of the Escarpment lands which form the Redhill

Creek valley walls and the Redhill Creek flood plain east of the landfill. See the enclosed plan for details. Results showed that:

- There were no signs of leachate spring breakout.

A second inspection of the subject lands was carried out by Mr. Jagger on May 5, 1981 and included the same points previously inspected. The inspection revealed that:

- There were several ground water seeps which appeared oily and reddish, and which had a strong odour.

- There were two pondings of surface water which had an oily scum.

These areas are shown on the enclosed map and are designated A to J. Following is a brief description of these areas:

- The spring, designated A, is located south of Albion Falls about 3 m below the level of Mountain Road. Flow was very slow, estimated at <1 L/min. There was no developed drainage away from the spring area. The water emanating from the seep was reddish in colour with an oily scum, and had a strong odour.

- The spring at location B emanated from the rock bed of Redhill Creek at an estimated rate of about 10 L/min. Again the water was reddish in colour.

- Location C consisted of a number of minor springs, seeps and pooled water around the concrete channel lining associated with a buried sewer pipe crossing. On the south side of the concrete lining, a reddish liquid was slowly oozing through the concrete, and also on the south side but immediately west of the lining was another small spring of reddish coloured water. The ground north of the lining was eroded and within this area there was a stagnant pool of reddish water.

- The springs at location D to H consisted of water seeps emanating from the bank at about the creek level. The seeps were not continuous but were frequent within the designated areas, and were oily but relatively clear.

- Areas I and J are surface water ponds on which local patches of light oily scum were observed. The patches of oil were discontinuous and covered less than an estimated 10% of the water surface. The water in the ponds was clear.

On October 26, 1981, the flood plain between the landfill and Albion Falls was inspected again by Mr. Jagger. Results of the inspection showed that:

- Springs were still present in areas A and C, although the character of area C had changed from May 5, 1981. This time there was only one spring which was located in the eroded area north of the concrete lining. The spring was clear and flowed at an estimated rate of 5 L/min.

- Area B was flooded because of the high creek water levels.

- There were no signs of the seeps at D through H.

- The surface water ponds I and J were expanded. A local oily scum was observed.

- The springs at A and C contain parameters such as phenols and PCB.

Based on our interpretation of the results of the monitoring as discussed above, it appears that the plume may possibly have reached the Escarpment face, at least locally. The springs at A and C contain parameters such as phenols and PCB which may originate at the landfill. However further investigation will be necessary for confirmation purposes.

There is a possibility that contaminant movement in the rock is channelized within fractures. One of these fractures may connect the springs at area A and C and monitor GM 6 which has registered significant gas. Also there is a zone in the Redhill Creek bed east of station SW3

where gas escapes, bubbling up through the water. This zone is also on this possible fracture plane. Other fractures may exist within the rock, paralleling the one described. These fracture planes if they exist could potentially provide a conduit for leachate movement in an easterly direction off-site. Since gas migration only occurs through the unsaturated zone, migration will likely be restricted. In this regard gas monitoring should be continued in GM6 as per section 3.3. Note that all of these observation points can be located along almost a straight line or lineation. However detailed drilling with continuous core recovery would be required to confirm fracture patterns in this area.

The presence of contaminants in surface water ponds and seeps along the creeks, locations D to J, is not confirmed at this time at all locations but is still suspected. Leachate moves away from the landfill through the rock which is covered by 1 to 3.5 m of soil in the flood plain east of the site. For leachate to discharge there would have to be an upward gradient in the rock and through the soil horizon.

We recommend further studies be considered by Gartner Lee Associates Limited. Specifically the following items should be included:

- *Mapping the extent of the contaminant plume. We suggest that the mapping can be carried out using piezometers and standpipes installed in boreholes and should be undertaken as soon as possible. Any further investigation should be co-ordinated with the work being carried out by the Upper Ottawa Street Landfill Site committee.*

- *The flood plain and Escarpment face should be inspected in May and November 1982 and 1983 by Gartner Lee staff in company with others if requested.*

- *Samples of any springs be collected and laboratory tested in May and November 1982 and 1983. As a check, samples could also be submitted to a referee laboratory if felt needed.*

- *Stream flow measurements be taken at each sampling period in order that mass balance (loading) calculations can be made for various parameters in the surface water. This would allow a far more appropriate analysis in addition to examination of concentrations above.*

2.5 COMBUSTIBLE GAS:

A review and analysis of the combustible gas monitoring results as shown on Table 7 indicate that:

- No combustible gas is present in the gas monitors except for gas monitor 6.

Methane gas is detected consistently in monitor 6, although the concentration is quite variable. The gas originates from the landfill and possibly migrates through a rock fracture away from the site. At this time, the methane does not present a hazard.

In view of these findings we recommend that:

- *A gas monitoring program be carried out according to the details in section 3.3.*

3.0 MONITORING PROGRAM:

As recommended in section 2.0 above a ground water, surface water and combustible gas monitoring program should be undertaken during 1982 and 1983. The elements of the program are described in the following sections. In general, the work components should be co-ordinated. As well, the results of the program should be reviewed and reported upon at the end of 1982 and 1983. At that time the program can be re-assessed and modified if necessary for the future. Proper records of the monitoring should be maintained.

3.1 GROUND WATER:

Ground water samples should be collected in May and November 1982 and 1983 from the following monitors:

Borehole 1 - Installation I
Borehole 2 - Installation I
Borehole 4 - Installation II
(replaces leachate pond)

Borehole 6 - Installation I
Borehole 9 - Installation II
Borehole 11 - Installation I
Borehole 12 - Installation I

The water samples should be analyzed for the following parameters: pH, conductivity, alkalinity, hardness, chloride, sulphate, ammonia, kjeldahl nitrogen, calcium, iron, phenols, PCB (aroclor 1254) and HCB.

Water springs, if present within the Redhill Creek flood plain, should be sampled at the same time and tested for the above parameters.

Water levels should be measured in May and November in all the monitors installed on and around the landfill.

3.2 Surface Water:

Surface water samples should be collected on the same day as the ground water sampling in May and November 1982 and 1983 from SW1, SW2, SW4 and SW7. The water samples should be analyzed for the following parameters: pH, conductivity, hardness, chloride, ammonia, kjeldahl nitrogen, BOD, iron and phenols. Stream flow measurements at stations SW1 to SW7 should be completed on the sampling day in order that mass balance calculations can be made for the various parameters in the surface water.

As recommended in section 2.3, sediment samples should be collected at SW1, SW2 and SW4 in November 1982 and 1983 and analyzed for PCB.

3.3 COMBUSTIBLE GAS:

Gas monitors GM 1 to GM 9 should be checked in January, March, May, September and November, 1982 and 1983 for combustible gas using a portable explosimeter.

4.0 RECOMMENDATIONS:

Following is a summary of the recommendations contained in the report.

- A ground water geochemical program should be carried out according to the details in section 3.1 of this report.

- A ground water monitoring program should be carried out according to the details in section 3.1 of this report.

- A surface water monitoring program, including stream flow measurements and mass balance calculations to fully assess the impact of leachate on the water

quality be carried out according to the details in section 3.2 of this report.

- Sediment samples at SW1, SW2 and SW4 be analyzed for PCBs in November 1982 and 1983.

- The extent of the contaminant plume should be mapped. We suggest that the mapping can be carried out using piezometers and standpipes installed in boreholes and should be undertaken as soon as possible. Any further investigation should be co-ordinated with the work being carried out by the Upper Ottawa Street Landfill Site committee.

- The flood plain and Escarpment face be inspected in May and November 1982 and 1983 by Gartner Lee staff in company with others if requested.

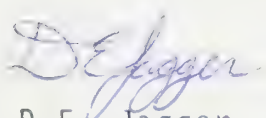
- Samples of any springs be collected and laboratory tested in May and November 1982 and 1983. As a check samples could also be submitted to a referee laboratory if felt needed.

- A gas monitoring program be carried out according to the details in section 3.3.

- A soil sampling program be initiated to identify the source of the PCBs in the area of Upper Ottawa Street adjacent to the landfill.

Prepared by:

GARTNER LEE ASSOCIATES LIMITED

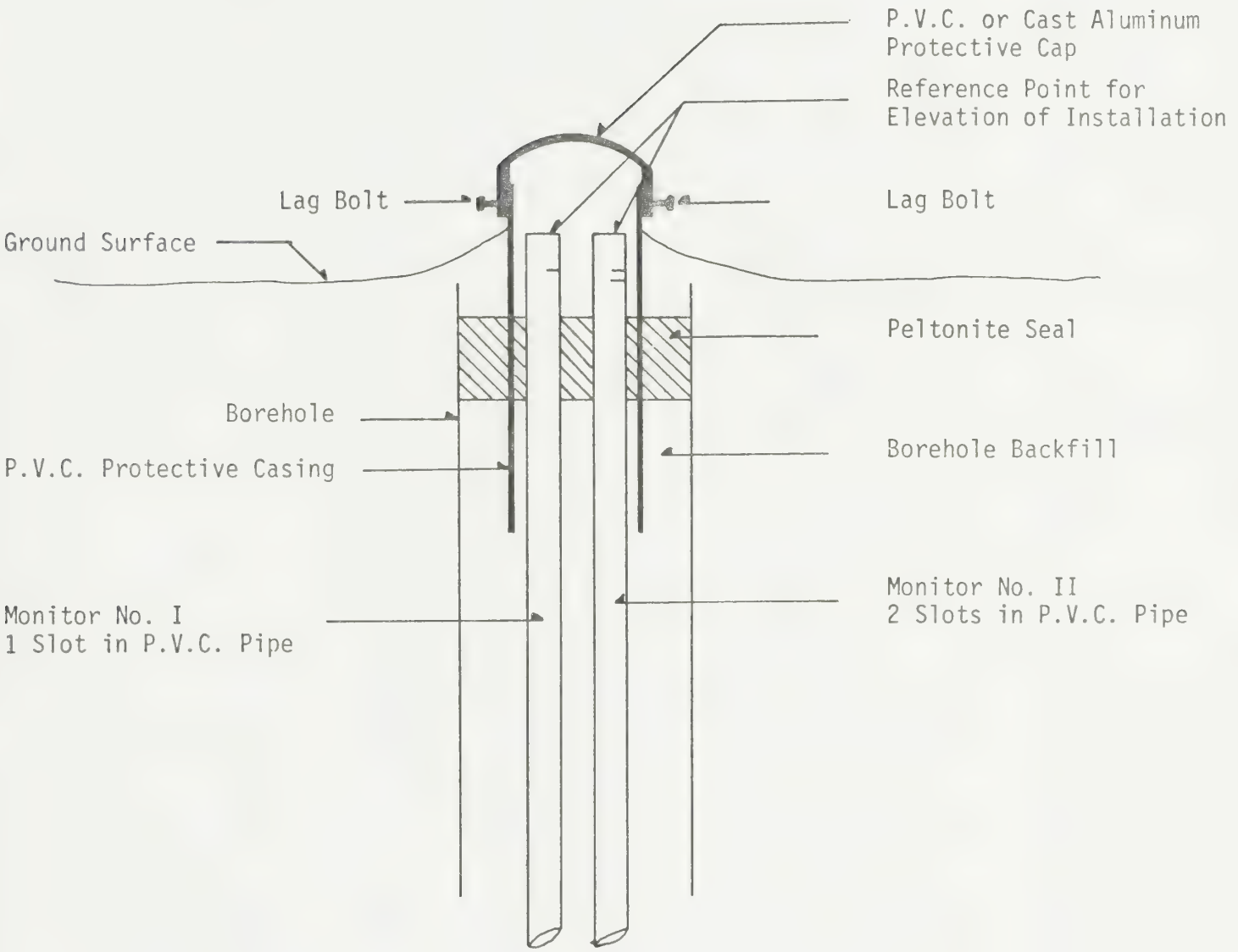


D.E. Jagger, P.Eng.,
Senior Project Engineer,
Associate.

APPENDIX

Ground Water
and
Gas Monitor Details

SURFACE DETAILS FOR PIEZOMETERS AND STANDPIPES



Note: All installations have been protected by casing

GROUND WATER MONITOR DETAILS *

Table 1

BOREHOLE NO.	MONITOR				LOCATION OF TIP		LOCATION OF SEAL	
	No.	Diameter(in)	Type	Elev. a.s.l.	Depth(ft.)	Elev.(a.s.l.)	Depth(ft.)	Elev. a.s.l.
1	1	1¼	●	656.4(ft)	37.5	618.9(ft)	35.0	621.4(ft.)
	11	½	CPVC ▲	656.4	20.0	636.4	20.0, 9.0,3.0	636.4,647.4 653.4
2	1	1¼	●	673.4	73.0	600.4	70.0,3.0	603.4,670.4
	11	1¼	▲	673.9	75.0	598.9	65.0,2.0	608.9,671.9
3	1	1¼	●	676.4	103.8	572.6	100.3,1.3	576.1,675.1
	11	1¼	▲	676.9	80.0	596.9	69.0,2.0	607.9,674.9
	111	1¼	▲	678.5	43.5	635.0	22.5	656.0
	1111	1¼	▲	678.5	22.5	656.0	2.5	676.0
4	1	1¼	●	675.0	99.8	575.2	93.8,1.8	581.2,673.2
	11	1¼	▲	675.2	85.5	589.7	75.0,2.0	600.2,673.2
5	1	1¼	●	657.0	79.0	578.0	75.0	582.0
	11	½	●	657.0	58.5	598.5	58.5,54.0	598.5,603.0
	111	½	▲	657.0	54.0	603.0	43.0,3.0	614.0,654.0
6	1	1¼	●	650.8	77.0	573.8	74.0	576.8
	11	½	●	650.8	67.0	583.8	67.0,63.0	583.8,587.8
	111	½	▲	650.8	50.0	600.8	50.0,38.0,3.0	600.8,612.8, 647.8
7	1	1¼	●	647.1	46.0	601.1	42.5	604.6
	11	½	●	647.1	25.5	621.6	25.5,21.5	621.6,625.6
	111	½	▲	647.1	19.5	627.6	19.5,8.5,2.5	627.6,644.6, 638.6
8	1	1¼	●	621.9	69.6	552.3	66.0	555.9
	11	½	CPVC ●	621.7	48.3	573.4	48.3,44.0	573.4,577.7
	111	½	CPVC ▲	621.9	24.2	597.7	24.2,13.0,1.0	597.7,608.9, 620.9
9	1	1¼	●	598.2	34.0	564.2	31.0	567.2
	11	½	●	598.1	21.9	576.2	21.9,19.9	576.2,578.2
	111	½	▲	598.1	19.9	578.2	8.9,2.9	589.2,595.2
10	1	1¼	●	596.4	42.0	555.3	39.0	558.3
	11	½	●	596.5	20.0	577.3	20.0,18.0	577.3,579.3
	111	½		596.5	18.0	579.3	7.0,4.0	590.3,593.3
11	1	1¼	●	602.6	53.0	549.6	59.0,	543.6
	11	3/4	●	602.6	22.0	580.6	22.0,17.0	580.6,585.6
	111	½	▲	602.5	10.0	592.5	3.0	599.5
12	1	1¼	●	N/A	19.0		17.0	
	11	3/4	▲	N/A	13.0		2.0	
G.M.1	1	½	▲	615.8	39.0	576.8	3.5	612.3
G.M.2	1	½	▲	622.2	39.0	583.2	2.5	619.7
G.M.3	1	½	▲	636.6	24.5	612.1	2.5	634.1
G.M.4	1	½	▲	636.6	24.5	612.1	2.5	634.1

● - Piezometer ▲ - Standpipe

Gartner Lee Associates Limited

* All measurements taken from the top of each monitor.

GROUND WATER MONITOR DETAILS

Table 1

BOREHOLE NO.	MONITOR				LOCATION OF TIP		LOCATION OF SEAL	
	No.	Diameter in.	Type	Elev. asl	Depth ft.	Elev. asl	Depth ft.	Elev. asl
G.M.5	1	½	▲	648.1(ft.)	22.0	626.1(ft)	5.0	643.1(ft.)
G.M.6	1	½	▲	650.5	22.0	628.5	5.0	645.5
G.M.7	1	3/4	▲	650.4	18.0	632.4	3.0	647.4
G.M.8	1	3/4	▲	N/A	18.0	N/A	1.5	N/A
G.M.9	1	3/4	▲	N/A	19.5	N/A	2.0	N/A

● - Piezometer ▲ - Standpipe

Gartner Lee Associates Limited

Geochemistry Results

PROVINCIAL WATER QUALITY OBJECTIVES

INORGANICS AND OTHER PARAMETERS

Conductivity	no objective
pH	6.5 to 8.5
Hardness	no objective
Chloride	no objective
Total Kjeldahl	no objective
Unionized Ammonia	0.02 ppm
Phenols	1 ppb
Nitrate	no objective
BOD	no objective
COD	no objective

HEAVY METALS

Cadmium	.0002 ppm
Chromium	.1 ppm
Copper	.005 ppm
Iron	0.3 ppm
Nickel	.025 ppm
Lead	.005 ppm - can be higher with alkalinity
Zinc	.030 ppm

REFERENCE: Water Management, Ministry of the Environment
November, 1978.

PROVINCIAL WATER QUALITY OBJECTIVES AND DETECTION LIMITS

PCB AND ORGANOCHLORINE PESTICIDES

	OBJECTIVE	DETECTION LIMIT
PCB	0	.020
HCB	.001	.001
-BHC	0.01	.001
LINDANE	0.01	.001
B-BHC	0.01	.001
HEPTACHLOR	.001	.001
ALDRIN	.001	.001
HEPT. EPOXIDE	.001	.001
THIODAN I	.003	.001
THIODAN II	.003	.001
pp DDE	.003	.001
DIELDRIN	.001	.001
ENDRIN	.002	.001
op DDT	0	.005
pp DDD	0	.005
pp DDT	0	.005
α - CHLORDANE	.06	.001
γ - CHLORDANE	.06	.001
MIREX	0	.005

Note: a) Objectives and detection limits in ppb

b) Water Management, Ministry of the Environment November 1978

UPPER OTTAWA LANDFILL WATER CHEMISTRY

	BH1-1		BH4-1		BH6-1		BH9-1		BH11-1		BH12-1		LEACHATE POND	
	T-6129	T-8681	T-6130	T-8682	T-6131	T-8683	T-6132	T-8684	T-6133	T-8685	T-6134	T-8686	T-6135	T-8687
pH	8.1	7.6	8.2	7.9	7.9	7.7	7.7	7.6	7.5	7.5	8.2	8.1	8.4	8.1
Conductivity (μmhos/cm)	4200	4170	9300	11,500	11,100	11,900	9000	8600	21,500	40,800	1100	4220	18,000	17,000
Alkalinity ($CaCO_3$)	294	186	650	1045	76	66	1420	1330	244	66	246	182	3810	4660
Total Hardness ($CaCO_3$)	1700	1740	1800	2010	3820	3680	2400	2190	7130	13,000	560	880	1100	1030
Chloride	112	113	2970	3510	3220	3560	1670	1570	6890	16,500	102	1030	3770	3570
Sulphate	2400	2300	240	39	1700	1400	2200	1500	1600	1300	230	410	1950	46
BOD_5	20	45	19	21	3	1.3	26	25	43	245	5	0.2	138	130
COD	37	690	446	580	97	105	360	384	230	471	32	22	890	1800
Total Phosphate P	0.02	<0.01	0.07	0.06	0.01	0.02	0.04	0.12	0.02	<0.01	0.01	<0.01	3.18	3.70
Ammonia N	3.7	3.6	6.0	209	4.8	3.99	140	128	6.6	10.1	0.45	0.02	430	460
Nitrate N	<0.1	<0.1	0.2	0.25	<0.1	0.10	0.3	0.20	<0.1	<0.25	0.1	0.15	1.4	0.85
Nitrite N	<0.01	0.01	<0.01	0.01	<0.01	0.02	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.20
Total Kjeldahl N	7.8	3.7	294	249	6.3	4.5	148	148	10.0	11.6	0.75	0.36	540	510
Calcium	344	417	195	226	1000	980	754	715	1630	3500	122	250	92	77
Cadmium	0.009	0.010	0.006	0.010	0.017	0.021	0.013	0.014	0.030	0.062	0.002	0.008	0.013	0.012
Copper	0.015	0.015	0.015	0.105	0.025	0.040	0.020	0.030	0.050	0.095	0.010	0.015	0.050	0.030
Lead	0.10	0.13	0.06	0.10	0.20	0.26	0.15	0.17	0.33	0.65	0.03	0.06	0.13	0.12
Manganese	0.38	0.08	0.26	0.41	0.66	0.55	0.13	0.095	0.91	0.44	0.29	0.24	0.56	0.53
Nickel	0.04	0.06	0.10	0.20	0.07	0.12	0.09	0.12	0.14	0.35	0.03	0.06	0.25	0.28
Magnesium	-	148	-	328	-	278	-	193	-	1120	-	83.0	-	250
Potassium	-	39.0	-	270	-	30.8	-	176	-	118	-	9.35	-	853
Iron	-	0.04	-	0.41	-	0.10	-	0.68	-	0.29	-	0.64	-	2.55
Sodium	410	422	1200	1450	1100	1250	970	995	2320	5000	470	535	2840	2880
Zinc	0.048	0.024	0.113	0.082	0.038	0.056	0.029	0.068	0.052	0.138	0.016	1.38	0.211	0.350
Phenol (μg/L)	99	7	87	62	23	7	32	5	23	3	25	7	640	235
PCB (Aroclor 1254) (μg/L)	0.20	0.17	<0.01	0.13	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.31*	0.69
HCB (μg/L)	<0.001	0.001	<0.001	0.003	<0.001	0.005	<0.001	0.003	0.005	0.007	0.002	0.012	0.004	0.012
pp'DDE (μg/L)	<0.001	<0.001	<0.001	0.004	<0.001	0.003	<0.001	0.005	<0.001	0.002	<0.001	0.001	<0.001	<0.001

Results reported as mg/L except where stated
* Aroclor 1254 and 1260

T-8681 - T-8687 Date Received: 28 May 1981
Date Analyzed: 15 June 1981

T-6129 - T-6135 Date Received: 26 November 1980
Date Analyzed: 16 December 1980

UPPER OTTAWA LANDFILL WATER CHEMISTRY

Table 3: Sheet 2

	SW1		SW2		SW 4	
	T-6064	T-8678	T-6065	T-8679	T-6066	T-8600
pH	8.2	8.2	8.1	8.2	8.0	8.2
Conductivity (µmhos/cm)	1700	1440	1560	1470	1350	2110
Chloride	178	170	209	190	232	395
Ammonia N	1.1	1.3	1.0	2.3	0.50	0.58
Total Kjeldahl N	3.9	2.2	5.3	3.3	0.52	1.1
Total Iron	0.97	0.08	1.8	0.13	5.7	0.44
Phenols µg/L	25	7	31	7	26	8
BOD_5	2.0	0.9	3.5	0.8	4.5	0.6

Results reported as mg/L except where stated

T-8678 - T-8600 Date Received: 28 May 1981
Date Analyzed: 15 June 1981

T-6064 - T-6066 Date Received: 26 November 1980
Date Analyzed: 16 December 1980

ORGANOCHLORINE AND PESTICIDE TEST RESULTS

Parameter	Detection Limit ug/L	Results
op' - DDT	0.001	Not Detected
pp' - DDD	0.001	
pp' - DDT	0.001	
Mirex	0.005	
Lindane	0.001	
Heptachlor epoxide	0.001	
gamma-Chlordane	0.001	
alpha-Chlordane	0.001	
Methoxychlor	0.01	

Notes:
1. Analysis by Beak
2. Test locations: Borehole 1, Installation 1
   Borehole 4, Installation 1
   Borehole 6, Installation 1
   Borehole 9, Installation 1
   Borehole 11, Installation 1
   Borehole 12, Installation 1
   Leachate Pond
3. Sampling dates: November 26, 1980
   May 28, 1981

Table 4

SEDIMENT SAMPLE RESULTS

Location \ Date	October 31, 1979	November 25, 1980	
SW1	Not Tested	0.017*	
SW2	244	0.90+	
SW4	662	0.39+	

Notes:
1. Concentrations in µg/g
2. *Aroclor 1260
3. +Aroclor 1254
4. October 31, 1979 analysis carried out by Peninsula Chemical Analysis.
5. November 25, 1980 analysis carried out by Beak.

WATER ANALYSIS RESULTS — Table 5

SPRINGS — November 3, 1981.

PARAMETER \ LOCATION	A	C	J
pH	7.46	6.85	7.23
Conductivity (μmhos/cm)	5,000	1,800	500
Alkalinity	456	328	336
Total hardness	1,150	670	330
Chloride	1,375	200	25
Sulphate	345	445	27
Bod_5	9.2	2.5	1.5
COD	324	29	29
Total phosphate	1.16	0.10	0.22
Ammonia	0.90	6.00	0.30
Nitrate	0.28	0.15	0.02
Nitrite	0.06	0.17	0.03
Total kjeldahl	5.60	5.40	0.60
Calcium	320	195	80
Cadmium	ND	ND	ND
Copper	ND	ND	ND
Lead	<0.1	<0.1	<0.1
Manganese	7.5	0.4	0.3
Nickel	ND	ND	ND
Magnesium	70	50	40
Potassium	7.8	7.6	1.2
Iron	14.0	0.7	0.3
Sodium	680	260	70
Zinc	0.3	<0.1	<0.1
Phenols (μg/L	91	46	105
PCB (Aroclor 1248) (μg/L)	0.41	ND	0.23
BHC (μg/L)	ND	ND	0.01
B-HCH (μg/L)	ND	ND	0.01

Results in mg/L unless otherwise noted.

Note: DDT, DDE, Dieldrin, Mirex tested but non-detected above the laboratory detection limit of 0.01 mg/L.

Ground Water Elevations

PROJECT 80-190 TABLE 6 SHEET 1

GROUND WATER ELEVATIONS (ft. a.s.l.)

BOREHOLE NUMBER	MONITOR No.	MONITOR Type	OCT 10 1979	OCT 31 1979	DEC 3 1979	JAN 7 1980	APR 7 1980	JUNE 13 1980	SEPT.4 1980	NOV.25, 1980	MAY 7, 1981		
1	I	●	627.5	626.4	626.0	628.0	627.2	626.4	626.3	626.5	626.8		
	II	▲	634.4	636.4	635.9	639.2	637.8	637.0	638.4	Dry	Dry		
2	I	●	613.4	613.4	614.4	616.1	616.8	608.4	607.0	Buried	-		
	II	▲	615.9	615.9	615.4	616.9	620.4	617.7	617.7	Buried	-		
3	I	●	603.4	604.1	610.1	611.1	610.9	608.0	destroyed	-	-		
	II	▲	615.1	616.9	Destroyed			—	—	-	-		
	III	▲							650.2	647.6	647.9		
	IIII	▲							658.2	656.9	657.1		
4	I	●	592.5	591.5	594.2	594.5	596.5	592.4	590.5	592.7	595.6		
	II	▲	616.7	617.0	615.7	616.7	614.7	615.0	610.0	615.4	615.2		
5	I	●	595.4	596.9	597.3	600.5	602.3	588.6	597.2	596.7	600.5		
	II	●	602.0	602.0	602.0	605.0	602.9	603.2	602.3	603.8	602.7		
	III	▲	605.2	613.0	616.0	618.9	613.0	613.9	612.9	613.4	603.7		
6	I	●	602.3	602.8	603.1	603.3	603.4	603.7	602.3	602.4	603.7		
	II	●	602.5	602.3	602.4	604.0	603.3	603.8	602.7	605.1	604.0		
	III	▲	638.3	635.8	635.3	637.5	637.0	636.7	634.6	633.1	637.2		

● – Piezometer ▲ – Standpipe

Gartner Lee Associates Limited

GROUND WATER ELEVATIONS (ft. a.s.l.)

BOREHOLE NUMBER	MONITOR No.	MONITOR Type	OCT 10 1979	OCT 31 1979	DEC 3 1979	JAN 7 1980	APR 7 1980	JUNE 13 1980	SEPT 4 1980	NOV.25, 1980	MAY 7, 1981		
7	I	●	606.6	606.8	608.5	608.1	609.1	608.0	608.9	609.4	612.5		
	II	●	625.1	626.1	627.9	628.0	629.6	628.3	628.1	627.6	629.3		
	III	▲	628.0	627.0	628.2	628.9	629.9	628.8	628.2	627.7	629.7		
8	I	●	598.7	600.6	601.9	602.1	603.4	602.5	602.6	601.0	602.8		
	II	●	598.5	600.9	602.3	604.3	604.2	605.6	603.7	601.5	603.4		
	III	▲	605.9	607.7	602.9	605.3	604.7	608.9	605.0	606.3	609.3		
9	I	●	590.7	589.6	591.8	591.7	594.3	592.5	591.2	590.8	593.2		
	II	●	591.0	590.0	591.9	592.0	594.3	592.5	591.4	590.2	593.4		
	III	▲	591.4	590.3	592.2	592.1	594.0	592.9	591.6	591.0	594.1		
10	I	●	586.6	586.4	588.0	587.9	Destroyed	—	—	-	-		
	II	●	587.2	587.7	588.5	588.8	Destroyed	—	—	-	-		
	III	▲	587.6	588.6	588.6	588.7	Destroyed	—	—	-	-		
11	I	●					599.2	595.5	594.7	594.1	596.3		
	II	●					599.2	596.1	595.7	594.9	598.2		
	III	▲					599.2	596.2	595.9	595.1	599.0		

● – Piezometer ▲ – Standpipe

PROJECT 80-190

TABLE 6 SHEET 3

GROUND WATER ELEVATIONS (ft. a.s.l.)

BOREHOLE NUMBER	MONITOR		OCT 10 1979	OCT 31 1979	DEC 3 1979	JAN 7 1980	APR 7 1980	JUNE 13 1980	SEPT 4 1980	NOV.25, 1980	MAY 7, 1981		
	No.	Type											
G.M. 1	I	▲	598.3	600.5	609.3	606.4	610.5	608.2	604.1	600.4	608.3		
G.M. 2	I	▲	603.7	607.0	602.7	605.3	609.2	608.8	605.1	606.2	609.4		
G.M. 3	I	▲	623.9	623.9	621.3	625.3	625.7	624.9	623.9	622.6	N/A		
G.M. 4	I	▲	630.2	630.4	631.8	631.8	629.2	631.5	632.0	633.0	634.4		
G.M. 5	I	▲	630.5	630.9	632.3	632.8	634.2	632.6	629.2	631.4	633.5		
G.M. 6	I	▲	633.7	634.7	637.1	637.2	639.1	636.2	641.6	636.0	638.3		
G.M. 7	I	▲					639.6	636.6	634.2	633.9	637.4		

● – Piezometer ▲ – Standpipe

Combustible Gas Results

Table 7

COMBUSTIBLE GAS RESULTS

LOCATION	Oct.10, 1979	Dec.3, 1979	Jan.8 1980	Apr.7, 1980	Sep.4, 1980	Nov.25, 1980	Jan.9, 1981	May 7, 1981
GM1	0%	0%	0%	0%	0%	0%	0%	0%
GM2	0%	0%	0%	0%	0%	0%	0%	0%
GM3	0%	0%	0%	0%	0%	0%	0%	0%
GM4	0%	0%	0%	0%	0%	0%	0%	0%
GM5	0%	0%	0%	0%	0%	0%	0%	0%
GM6	90%	0%	0%	12.5%	70%	5%	90%	10%
GM7				0%	0%	0%	0%	0%
GM8						0%	0%	0%
GM9						0%	0%	0%

Note: Percent concentration by volume of methane

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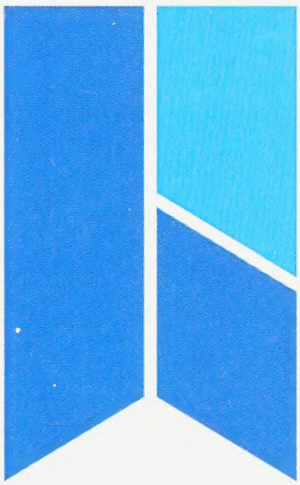

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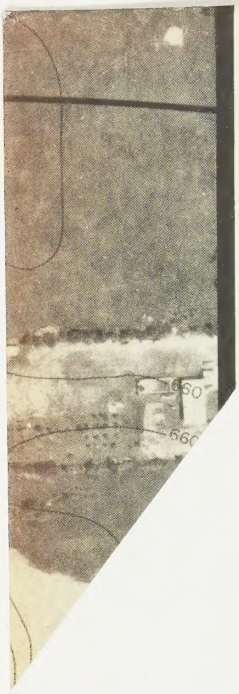

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